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# VACUUM EVAPORATION OF PORCELAIN MIXTURE IN PRODUCTION OF PORCELAIN INSULATORS

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The process of vacuum evaporation of porcelain mixtures on vacuum presses and the ways for improving the production of porcelain insulators are considered. A calculation of unit molding pressure is proposed; the pressure distribution along the press and depending on the moisture of the mixture is indicated.

The typical features of fine ceramics include homogeneity and increased density, absence of pores, and good insulating and electric characteristics.

For the purpose of obtaining a plastic porcelain mixture with homogeneous moisture, it is kneaded in a vacuum press. The moisture of a mixture affects its molding properties, the strength of raw clay bar, shrinkage, the strength of dried and fired products, thermal conductivity, and water absorption.

The optimum moisture of argillaceous materials depending on their properties varies within the limits of 18 – 23%. Porcelain insulators are produced from mixtures of moisture 18 – 19%. The effect of vacuum evaporation of a mixture depends on its composition, the degree of vacuum, and the duration of treatment in the vacuum chamber. The volume of air in a freshly prepared porcelain mixture before vacuum treatment is 5.0 – 15.0% and after vacuum evaporation it has to be 0.3 – 4.0% [1].

Vacuum treatment decreases textural heterogeneity, increases plasticity, improves the molding properties of mixture, and decrease its vacillation to nearly one-third. The optimum rarefaction for treating most fine ceramic mixtures is 96 – 100 kPa. Many manufacturers do not maintain this level of rarefaction, which impairs the quality of molded and fired products. Plastic porcelain mixtures in the form of cylindrical lumps weighing 16 – 20 kg after vacuum treatment should be stored in special enclosed basements (without draught) and age for 6 – 8 weeks (which is not often complied with). During this period the plasticity and moldability of mixtures improve, which is important for molding, especially for large-size insulators. A vacuum-treated mixture has lower shrinkage, its firing temperature is 20 – 30°C lower than that of nontreated mixtures. The mechanical strength of unfired mixture grows up to 5 MPa [1]. After that a secondary kneading of mixture is performed.

Some porcelain manufacturers in their attempts to avoid cracking of products in drying and firing use rather long nozzles (up to 0.5 m and more) without thinking that each type of a vacuum press develops a structure with characteristic quasi-isotropic rings. The motion of a ceramic mixture inside such long nozzles is laminar, which means that resistance to its motion at the periphery near the nozzle walls grows and causes partial inner stratification. In the case of a sharply expressed orientation of particles, molded preforms may acquire a cord (laminar) structure, elliptical or

S-shaped, i.e., nonuniformly consolidated across the channel section. An essential disadvantage in producing porcelain insulators is using vacuum presses that do not provide sufficient vacuum evaporation of mixtures, such as Kema presses (Germany). This press performs vacuum evaporation only in the upper layers of a cylindrical clay mixture, therefore, a substantial amount of air persists in its lower non-vacuum-treated layers, which produces defects in molded and fired products.

The stratification of a preform may be caused by heating the mixture inside the press, which should not exceed 4 – 6°C.

In practice, to guarantee a standard quality of mixtures released from the vacuum press, apart from monitoring the vacuum gage data, one should periodically cut off a plate of thickness 10 – 20 mm with a wire knife and subject it to uniform stretching [2]. In the case of an adequately vacuum-treated mixture, this plate should have no stratification, cracks, or large pores (holes).

To ensure normal operation of a vacuum press, mixtures should be uniformly fed into the press hopper. One should constantly pay monitor the vacuum gage that indicates rarefaction inside the vacuum chamber.

Insufficient rarefaction in the vacuum chamber may be caused by a faulty vacuum pump, an overfilled chamber, a disturbance of airtightness (faulty glands, faulty oil gate, etc.), penetration of water into the vacuum chamber (water may penetrate there in the case of unexpected stops of the vacuum pump). It is necessary as well to systematically check the state of the feeding and compressing screws and

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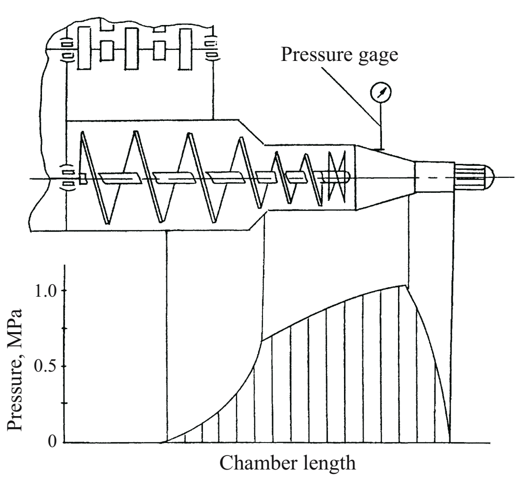


**Fig. 1.** Pressure distribution along the chamber length.

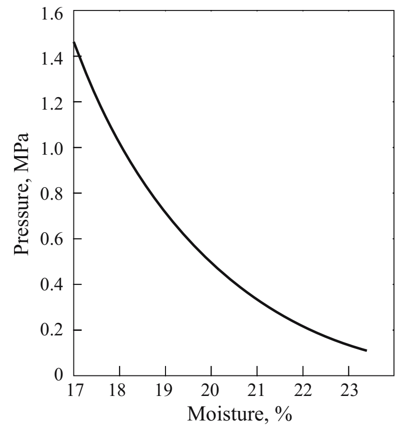


**Fig. 2.** Variation in unit molding pressure depending on mixture moisture.

maintain a clearance between the blades and the cylinder of the press, which should not exceed 2 – 3 mm.

Vacuum evaporation in the production of porcelain insulators should be performed on presses CMK-133, CMK-168, CMK-443A, CMK-376, K/$S_t$SV (Thuringie), K/$S_t$SV 350/1, etc. These presses have pressure gages located in the cylinder head and connected to the automatic water feed into the mixer; the vacuum chamber has a special mixture level gage (other parameters are monitored as well).

Apart from the specified reasons and methods for their elimination, based on preliminary calculations, pressure in the press should be brought in accordance with mixture moldability and the screw blower should be adjusted. Measures preventing cord formation include the introduction of grog components increasing the inner friction coefficient and decreases the propensity of mixture to stratification, the increase in the moisture of the mixture contributing to its adhesion, the decrease in the external friction by introducing surfactants, the elongation of the press head by inserting a ring 100 – 200 mm long between the cylinder and the head, which contributes to the homogeneity and higher densification of the mixture.

The ratio between the cross-section areas of the nozzle and the press body ensuring the optimum densification of mixtures with minimal texture defects has to be equal to 1 : 4.

Since a concentric structure is formed at the very first stage of molding (molding a cylindrical mixture in the vacuum press), special methods and a device for forced texturing of the mixture have been developed. For this purpose, a texture modifier is installed on the vacuum press after the second screw, instead of the nozzle. The mixture pushed by the screw is divided into several flows (depending on the number of cylindrical preforms needed) and each of them is channeled into a separate pipe which at the beginning is shaped as a sector and at the end has the shape of a circle with the same cross-section area, The total cross-section area of all pipes is equal to the cross-section area of the screw cylinder. The mixture treated in this way arrives at the nozzles of required sections [1].

Unit molding pressure depends on the physicomechanical properties of mixture (mainly, its plasticity), the diameter of press (screw) cylinder, the length of the press head and the nozzle, and mixture moisture. Unit molding pressure (MPa) can be calculated using the following formula [3]:

$$P = 0.1k_1 k_2 (0.215W^2 - 10.62W + 130.5 + 11.8D^2),$$

where $k_1$ and $k_2$ are coefficients accounting for the length of the head and the nozzle, respectively; $W$ is the moisture of ceramic mixture, %; $D$ is the diameter of the squeezing blade of the screw, m.

With mixture moisture equal to 18%, the diameter of the squeezing screw blade 0.45 m, $k_1 = 1$, and $k_2 = 0.91$, the maximum pressure in the press is equal to 1.036 MPa.

The maximum unit pressure can reach 1.4 – 1.5 MPa depending on the moisture of the mixture and the design of the press.

Figures 1 and 2 give practical and calculated data for determining the unit molding pressure along the press for screw diameter 0.45 m, the press head 0.25 m long, and the nozzle length 0.20 m.

In production it is necessary to take into account the type of the product, monitor the operation of the vacuum press, select the number of strokes of the squeezing screw blade. An increased number of strokes increases the homogeneity the mixture pushed through the head and the nozzle, however, at the same time it may raise the resistance to the mixture passing through the squeezing blade and, accordingly, to lower the press efficiency. Therefore, in each specific case it is necessary to experimentally establish the number of required strokes of the squeezing blade to ensure normal operation of the press.

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